Observed HR diagrams and stellar evolution: the interplay between observational constraints and theory
ASP Conference Series, Vol. ???, 2001
Thibault Lejeune and João Fernandes, eds.

Temperature predictions for dust embedded AGB stars: how far can we go with synthetic near-infrared photometry ?

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Abstract.
We discuss the possibilities of the BaSeL models in its lowest temperature boundary (T_{eff}∼2500 K for cool giants) to provide the T_{eff} of AGB stars. We present the first step of our work, by comparing our predictions for the AGB star R Fornacis with the results of Lorenz-Martins & Lefèvre (1994) based on the dust spectral energy distribution.

1. Introduction

Main sequence stars with mass in the range 0.9-9 $M_\odot$ evolve through a double shell burning phase, refered to as the asymptotic giant branch (AGB) phase of evolution. This phase is characterized by carbon dredge up of the core to the surface after each thermal pulse - Helium shell flash - (Iben & Renzini 1983).

The temperatures of these objects are very badly known. Although they are highly variable, their determination from static models such as assumed in the BaSeL library can be justified as a first approximation. In order to explore the capabilities of the BaSeL library (Lejeune, Cuisinier & Buser 1997, 1998 and references therein, see also Lastennet, Lejeune & Cuisinier, these proceedings) to predict correct temperatures for such cool AGB stars, we compare our results from synthetic infrared photometry of the stellar photosphere with the detailed study of Lorenz-Martins & Lefèvre (1994) of the AGB carbon star R Fornacis. Their work is based on a modelling of the spectral energy distribution of the dust envelope, where they put tight constraints on the temperature of the heating source.

2. R Fornacis as a test case

Table 1 gives the JHKLM photometry of R For (HIP 11582) that we used (Le Bertre, 1992). The photometric errors in the individual JHKLM magnitudes are not provided so we assume an error of 0.2 on each magnitude, according to the maximum uncertainty estimated from Fig. 1 of Le Bertre (1988).

Table 1. Infrared JHKLM photometry (Le Bertre, 1992, Julian date 7643) and effective temperature of the central star of R Fornacis.

J	H	K	L	M	$T_{eff}^{(1)}$ (K)	$T_{eff}^{(2)}$ (K)
5.76	3.97	2.32	0.21	−0.28	2650	2440-2520

$^{(1)}$ Lorenz-Martins & Lefèvre (1994);
$^{(2)}$ BaSeL JHKM synthetic photometry (this work, see text for details).

3. Method

Although the dust may have a significant contribution in the IR *bands* of this star, especially L and M, it should only have a secondary influence on the photospheric *colours*. We intend of course to correct for the predicted differences by a dust model (Lorenz-Martins & Lefèvre, 1993) due to the envelope. However in a first step we merely compare the observed colours of R Fornacis with the photospheric predictions of the BaSeL library (BaSel-2.2 version, with spectral corrections) by minimizing their χ^2 differences.
This χ^2-minimization method is similar to the one applied in Lastennet et al. (2001): we derived the T_{eff} and log g values matching simultaneously the observed JHKLM photometry listed in Tab. 1, assuming a solar metallicity ([Fe/H]=0).

4. Preliminary results

We have tested various colour combinations of the J (1.25 μm), H (1.65 μm), K (2.2 μm), L (3.4 μm), and M (5.0 μm) magnitudes: (J−H), (H−K), (K−L), (J−K) and (K−M). They all give T_{eff} estimates in agreement with the work of Lorenz-Martins & Lefèvre (1994).
Since better constraints should be obtained by matching more than 1 colour, we chose the (J−H) and (K−M) colours which give the best χ^2-scores. The solutions we get to match simultaneously the observed (J−H) and (K−M) are presented in Fig. 1. Our best BaSeL-infrared solution is T_{eff}=2440K[1], but all the solutions inside the 1-σ contour are good fits to the observed photometric data. The effective temperature of the central star of R For found by Lorenz-Martins & Lefèvre is T_{eff}=2650 K (shown as a vertical line on Fig. 1). This is larger by ∼100K than the 1-σ BaSeL contour but still inside the 2-σ contour. Additionally the BaSeL models show that this star has a surface gravity log g $\sim -0.5 \pm 0.4$, which is what one expects for carbon stars.

[1]Note: for giants, BaSeL solutions cooler than 2500K are extrapolated.

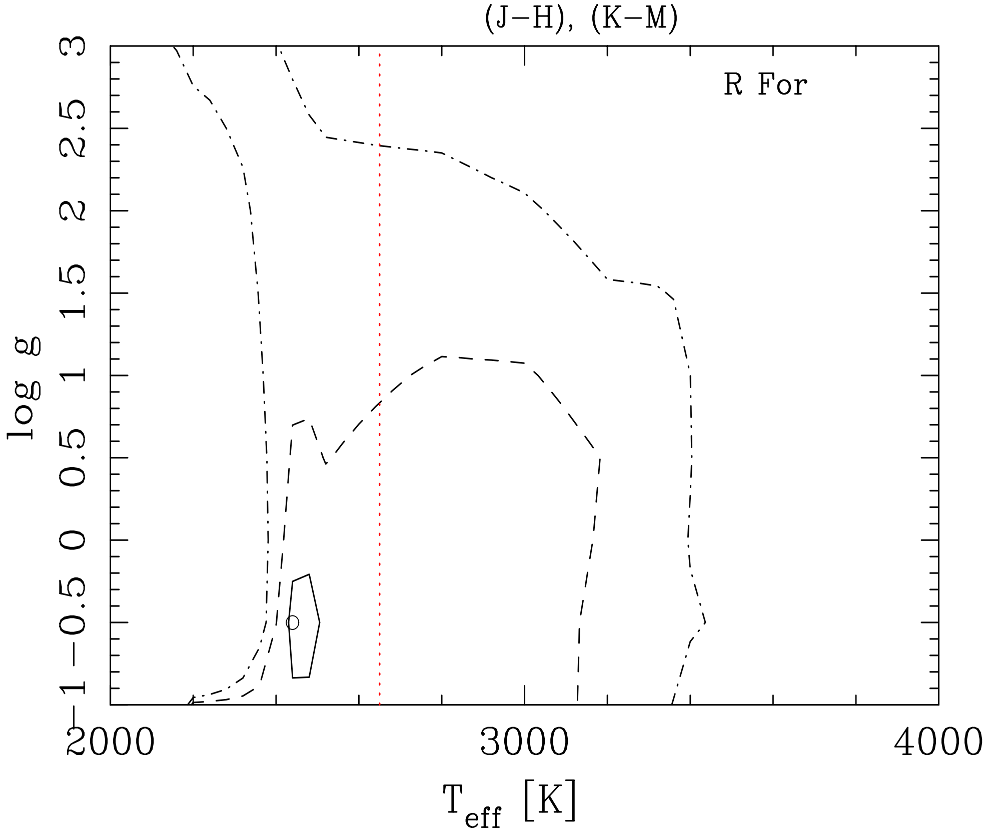

Figure 1. Determination of the temperature and surface gravity of R Fornacis from the infrared synthetic photometry of the BaSeL models. The best solutions are inside the 1-σ contours defined by a small region (solid line). The 2- (dashed line) and 3-σ (dot-dashed lines) are also shown. The determination of Lorenz-Martins & Lefèvre (1994) is displaied as a vertical dotted line at T_{eff}=2650 K for comparison.

5. Conclusion

We reported a preliminary study to determine the T_{eff} and surface gravity of the central star of R Fornacis by exploring the best χ^2-fits to the infrared photometric data. These results are in a surprising good agreement - given the approximation we made (no envelope absorption/emission correction) - with the detailed study of Lorenz-Martins & Lefèvre (1994). Therefore, while detailed spectra studies are obviously highly preferred (see e.g. Loidl, Lançon & Jørgensen, 2001), our method may provide a good starting point. If our R Fornacis result is confirmed with other AGB stars, this would mean that the BaSeL JHKLM synthetic photometry is suited to derive (Teff-log g) estimates for cool AGB stars.

Acknowledgments. EL acknowledges support from CNPq and FAPERJ, and thanks the conference organizers for a stimulating meeting and for financial support.

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